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Comparative Nutrient Budget of the Two Branches of Canagagigue Creek: Task C, Project No. 19, Part B

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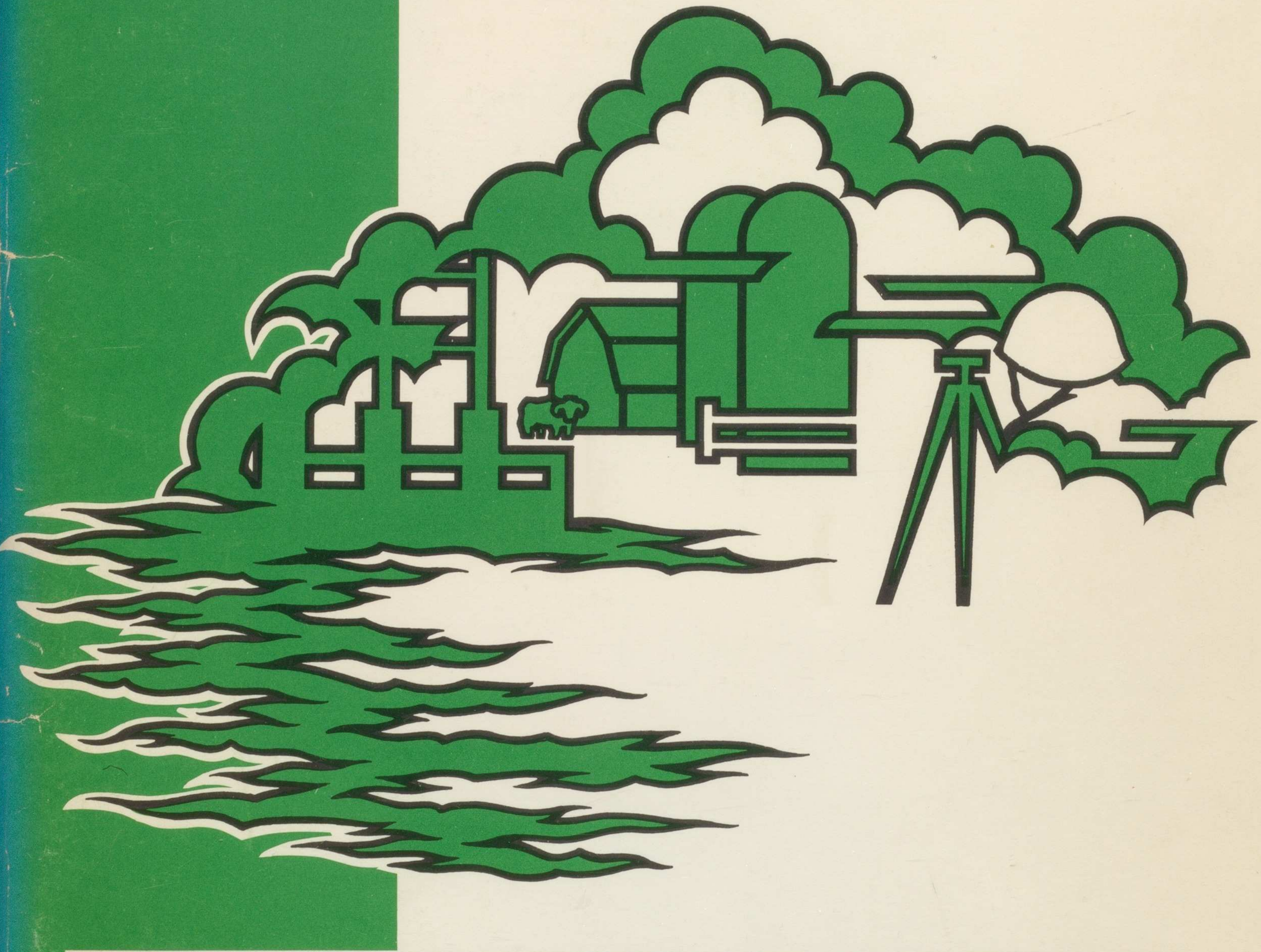
INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES



INTERNATIONAL JOINT COMMISSION

COMPARATIVE NUTRIENT BUDGET OF THE TWO BRANCHES OF CANAGAGIGUE CREEK

OFFICE OF RESEARCH ADMINISTRATION

UNIVERSITY OF WATERLOO

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COMPARATIVE NUTRIENT BUDGET OF THE TWO BRANCHES OF CANAGAGIGUE CREEK

SPONSORED BY THE ONTARIO MINISTRY

OF AGRICULTURE AND FOOD IN

SUPPORT OF THE POLLUTION FROM

LAND USE ACTIVITIES REFERENCE GROUP

TASK C

PROJECT NO. 19, PART B

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Disclaimer

The study discussed in this report was carried out as part of the efforts of the Pollution from Land Use Activities Reference Group, an organization of the International Joint Commission, established under the Canada-U.S. Great Lakes Water Quality Agreement of 1972. Funding was provided through the Ontario Ministry of Agriculture. Findings and conclusions are those of the authors and do not necessarily reflect the views of the Reference Group or its recommendations to the Commission.

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Summary

The quantities of drifting solid organic matter (S.O.M.) in two size particle ranges were sampled weekly for 13 months at four stations on the upper reaches of the Canagagigue Creek. Two stations were located on each of the East and West branches of the creek.

The particle size ranges sampled were 1.3 - 3.0 cm and 253 micron - 1.0 cm. The material within these size ranges was divided into recognizable fractions: green, coniferous, deciduous algae, detritus and aquatic animals. Nutrient analyses were conducted on monthly bulked fraction samples. S.O.M. was analyzed for percent organic matter, percent Kjeldahl nitrogen in the organic matter and percent total P in the organic matter.

Allochthonous leaf fall inputs to each branch of the stream are calculated. These inputs are compared with the outputs of deciduous material as particles of diamter 1.0 - 3.0 cm on the East Branch (Hynes and Dance 1976). This study shows that less than 1% of the calculated allochthonous input drifts downstream as 1.0 - 3.0 cm particles during a year. Further, deciduous and for that matter all fractions of material do not seem to drift downstream for very long distances. The nutrients contained within the leaf litter probably drift downstream primarily as dissolved organic matter or to some extent as detrital particles.

Nutrient analyses of the S.O.M. fractions indicate that drifting plant material in the Canagagigue contains organic matter, N and P in quantities comparable to those in live plants.

Bedload sampling indicates that significant quantites of material are transported along the stream bottoms of both of the branches.

The discharge regime of each stream seems to be the controlling factor in downstream transport. Discharge in turn is controlled by precipitation and season. The greatest discharge occurred as a direct result of precipitation and spring snow melt.

At station 1 (upstream East Branch) 80% of the annual coarse S.O.M. (1.3 - 3.0 cm) and 95% of the annual fine S.O.M. (253 micron-1.0 cm) transport occurred during the spring flush.

Total dry weights for the downstream drift of S.O.M. as 253 micron - 3.0 cm particles over a thirteen month period (June 1, 1975 - June 30, 1976) at two stations of the east branch Canagagigue Creek are as follows: Station 1 - approx. 32,000 kg
Station 2 - 5,234.03 kg

At station 1 this material contained 399.63 kg of N in the organic matter and 51.58 kg of phosphorus in the organic matter. At station 2 the dry weights were 64.67 kg N and 8.60 kg P in the organic portion of drifting S.O.M. Animals made small contributions to the dry weights of S.O.M. but made greater contributions to the nutrient totals.

Year round sampling could not be conducted successfully at stations 3 and 4. Thus a comparison of nutrient transport on a yearly basis cannot be made. However complete sampling was achieved between June 1 - December 30, 1975 and March 29 - June 30, 1976 at stations on both the East and West Branch. During the summer and fall of 1975 the greatest amounts of S.O.M. drifted past the downstream West Branch station, approximately 3,350 kilograms. The next highest quantity moved past Lower East but was only about 800 kilograms. During the spring flush greater quantities of material were transported past Upper East than Lower East. The largest quantities of material which moved during late spring and early summer 1976 did so at station 2 (Lower East).

These results indicate that the quantity of material which drifts past a particular station depends upon the season, since high discharges were experienced at all stations simultaneously.

Agricultural plant material was not found to contribute a significant amount of material to the stream.

The fraction which contributed the greatest quantities of S.O.M. and nutrients was that of detritus and algae in the particle size range 253 microns - 1 cm. This fraction contained organic detritus as well as quantities of inorganic material which had been churned up from the stream bed.

Introduction

In the present study we attempted to determine and compare the quantities of solid organic material (S.O.M.) and nutrients contained therein, which drifted downstream in two streams flowing through sub-watersheds with slightly different land use activities. The East Branch sub-basin contains agricultural land but most of the stream bank is forested; whereas the West Branch watershed is entirely farmland.

Kemp (1968) states that "significant quantities of phosphorus may pass downstream...as portion of bed-loads, or as floating materials". We attempted to quantify this in terms of Kjeldahl nitrogen and total phosphorous in the organic matter.

Egglishaw (1971) found that the absolute abundance of microscopic detrital particles in a Scottish stream increased downstream during flood conditions. Thus presumably organic matter drifting in Southern Ontario streams will eventually reach the Great Lakes. At least the nutrients contained within the organic matter will move downstream. However, two reservoirs are located on the Canagagigue Creek downstream of the study area.

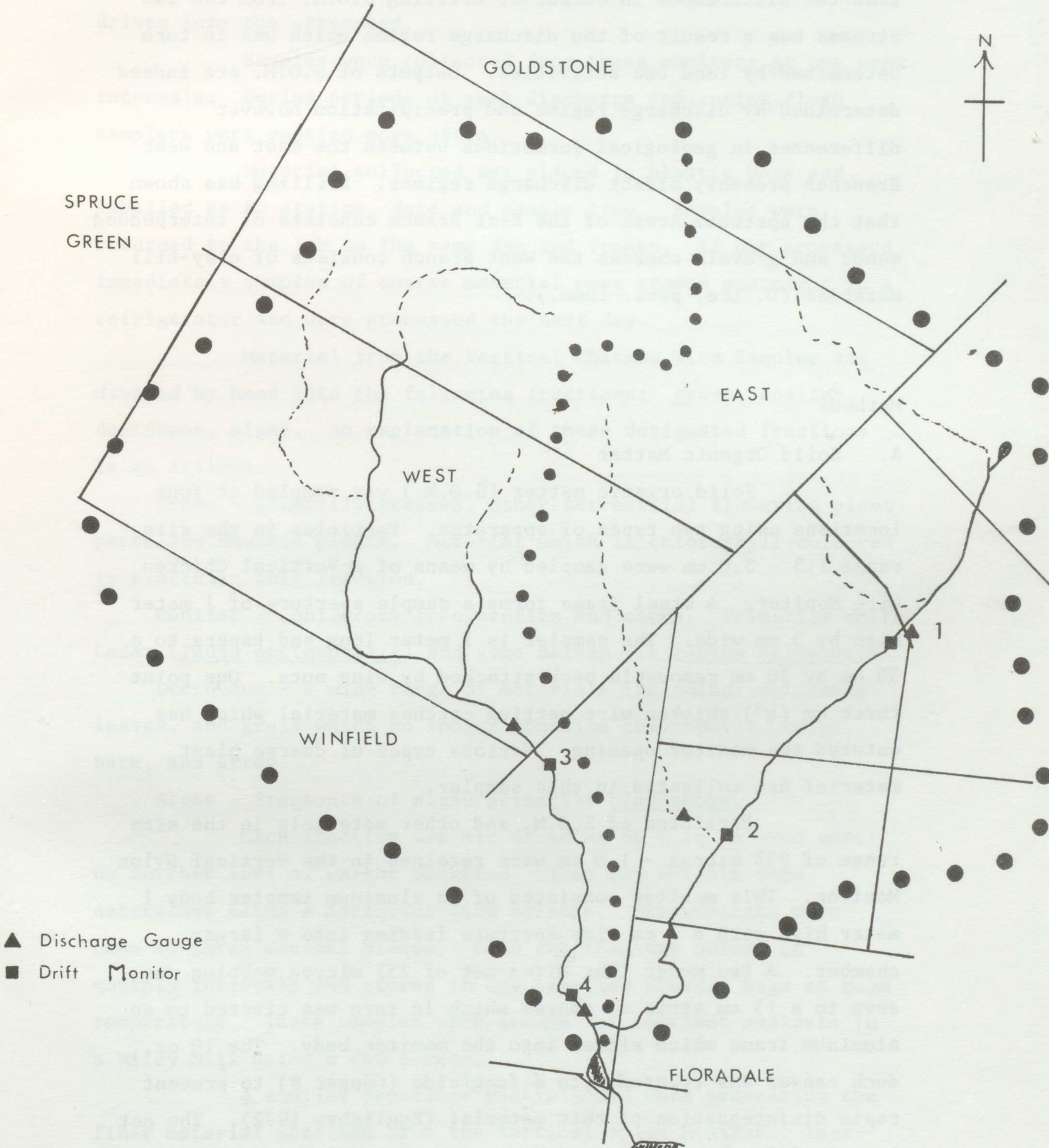
Figure 1 depcits the sites of discharge gauges and drift monitor stations in the upstream reaches of the Canagagigue Watershed.

We were not successful in sampling the spring flush at stations 3 and 4 in 1976. Another attempt is to be made in the spring of 1977 using apparatus fixed to concrete bridges. The dry weights of material drifting past stations 3 and 4 during the flood of 1977 will be available upon request.

Kenneth Dance (Department of Biology, University of Waterloo) has determined the number of taxa and individuals of aquatic organisms drifting at stations 1, 2, 3, 4 during the study period. As well, the emergence of adult aquatic insects was monitored during 1976. This biological information is also available upon request.

FIGURE 1

STUDY AREA



At the time progress report #3 was produced we felt that the differences in output of drifting S.O.M. from the two streams was a result of the discharge regime which was in turn determined by land use activities. Outputs of S.O.M. are indeed determined by discharge regime and precipitation however differences in geological formations between the East and West Branches probably affect discharge regimes. Drilling has shown that the upstream areas of the East Branch consists of interbedded sands and gravels whereas the West Branch consists of clay-till material (D. Lee, pers. comm.).

Methods

A. Solid Organic Matter

Solid organic matter (S.O.M.) was sampled at four locations using two types of apparatus. Particles in the size range 1.3 - 3.0 cm were sampled by means of a Vertical Chicken Wire Monitor. A steel frame forms a sample aperture of 1 meter high by 3 cm wide. The sampler is 1 meter long and tapers to a 30 cm by 30 cm removable back attached by wing nuts. One point three cm (½") chicken wire netting catches material which has entered the monitor opening. Various types of coarse plant material are collected in this sampler.

Particles of S.O.M. and other materials in the size range of 253 micron - 1.0 cm were retained in the Vertical Nylon Monitor. This monitor consisted of an aluminum sampler body 1 meter high with a 1 cm wide aperture leading into a larger chamber. A two meter long Nitex net of 253 micron webbing was sewn to a 15 cm strip of canvas which in turn was riveted to an aluminum frame which slides into the monitor body. The 10 oz. duck canvas was treated with a fungicide (Copper 8) to prevent rapid disintegration of this material (Egglishaw 1972). The net length of 2 meters prevented formation of a standing wave in the sampler mouth and allowed for a long sample interval.

Both samplers were attached to ½ inch steel pipe driven into the streambed.

Samples were collected from these monitors at one week intervals. During periods of peak discharge and spring flush samplers were emptied more often.

Material collected was placed in plastic bags and labelled as to station, date and sample type. Samples were returned to the lab on the same day and frozen. If not processed immediately samples of coarse material were stored overnight in a refrigerator and were processed the next day.

Material from the Vertical Chicken Wire Sampler was divided by hand into the following fractions: green, conifer, deciduous, algae. An explanation of these designated fractions is as follows:

Green - primarily grasses, other terrestrial flowering plant parts and aquatic plants. Material which is chlorophyll-coloured is placed in this fraction.

Conifer - coniferous tree needles and cones. Primarily White Cedar (Thuja occidentalis) and some Balsam Fir (Abies balsamea).

Deciduous - a wide range of materials including: deciduous leaves, and grass which no longer contains chlorophyll, twigs, bark, and straw.

Algae - fragments of algae primarily Cladophora.

Each fraction was air dried at 60°C in an oven until no further loss of weight occurred. Then dry weights were determined using a Sartorius 1400 balance. Measurements were made to three decimal places. Each fraction was bulked in monthly intervals and stored in dry labelled plastic bags at room temperature. These samples were ground for nutrient analysis in a Wiley Mill using a #40 screen.

A similar procedure was followed when processing the finer material obtained from the Vertical Nylon Monitor. This material was divided into the same categories as the coarse material except that a detritus fraction existed. The algae fraction was not removed and was weighed with the detritus fraction which consisted of particles of green, coniferous and deciduous material which were too small to be grasped with forceps, particulate organic material including aquatic organisms and inorganic material (e.g. sand).

Aquatic organisms were picked by hand from the thawed samples. Floating techniques could not be used since $CaCl_2$ or sugar would affect the analysis of detritus for nutrients. Organisms for nutrient analysis were collected from the East Canagagigue Creek by kick sampling. Coarse material was swished in water to remove any attached organisms. Algae were left with the detritus since during the summer large numbers of chironomid larvae and other organisms were often found among the algal fragments.

Each nylon monitor fraction was oven dried and dry weights were determined on a Sartorious 1400 balance. Detritus and algae fraction weights were often determined on a Metler P 1000 balance to an accuracy of one decimal point. Fractions were bulked in monthly intervals and ground for nutrient analysis in a Wiley mill.

B. Nutrient Analyses

Percent organic matter was determined by the loss on ignition technique.

Percent Kjeldahl nitrogen and percent total phosphorus was determined by wet digestion of ground samples. Digestion was with concentrated sulphuric acid on a hot plate. Hydrogen peroxide was also utilized. Kjeldahl nitrogen and phosphorus determinations were made on an auto analyzer (Thomas et al 1967).

C. Bogardi Bedload Sampler

To supplement the information of drift through the water column fluvial sediment (both organic and inorganic) moving along the stream bottom was monitored by means of a Bogardi Bedload Sampler. Two samplers of sheet aluminum construction with flip-up backs were used. The design followed was that similar to those used by Canada Agriculture with several modifications, i.e. no tail fin, guy wires or plexiglass side.

Samplers were emptied at various intervals depending upon the flow regime. Samples were transported to the lab in plastic bags and were frozen until processed. Thawed samples were separated into size fractions by wet sieving. Each fraction was oven dried and weighed on a Mettler P 1000 balance.

D. Physical Data: Discharge

Water velocity was measured at 10 cm intervals along the aperture of each vertical monitor on each sample date with a portable electronic velocity meter (Edington 1960). The depth of water at the mouth of each monitor was also recorded. Using these data and numberical integration (Simpson's Rule) the volume of water passing through each monitor on the sample day could be determined. To estimate discharge through the monitor during the sample interval the values for the discharge at the two sample dates were averaged.

The percentage of total discharge sampled by the chicken and nylon monitors was determined by comparison of the volume passing through the monitor with the mean weekly total discharge.

The total discharge values were measured by the following agencies:

Station 1 - School of Engineering, University of Guelph

Station 2 - Canada Water Survey (035) minus U. of Guelph gauge on tributary (E_2)

Station 3 - Canada Water Survey (036)

Station 4 - School of Engineering, University of Guelph

Total discharge figures for stations operated by the School of Engineering, University of Guelph for the 1975 sampling season were not available at the time this report was prepared. Discharges of these stations for 1975 were interpolated from graphs constructed by comparing University of Guelph and Canada Water Survey data obtained in 1976 with the Canada Water Survey 1975 data. When such interpolations were necessary the total discharge on the drift sample collection dates only was determined. As with the volume passing through the monitors total discharges were calculated by averaging the discharges for two dates at either end of the sample interval.

However where complete and reliable daily discharge data were available (stations 2 and 3 1975 and 1976, stations 1 and 4 April 10 1976 - June 30 1976) total discharge during sample intervals was the mean of the daily discharges for dates within the interval.

E. Statistical Analyses

The nutrient analysis data were examined to see if any trends were present. A paired t-test was used to determine whether there was a significant difference between the nutrient contents of fine and coarse S.O.M. The June-December, 1975 data for station 2 were subjected to analysis of variance to determine whether there was a significant difference in the percentage of organic matter, Kjeldahl nitrogen or total P between types of material. Analysis of variance was also used to compare the annual means of L.O.I., % N, %P to determine whether there is any difference in nutrient contents of materials among the four stations.

Results

Table 1 shows the calculated dry weights (kg) of S.O.M. and aquatic organisms moving downstream past each station. Particle size 253 micron - 1.0 cm.

The monthly contribution of each material fraction to the total calculated S.O.M. is shown in Tables 2A through D.

Nutrient analysis results are summarized in Table 3. The mean percentage of organic matter, Kjeldahl nitrogen in the organic matter and mean percentage total phosphorous in the organic matter for the fractions at each station during the 13 month sampling period are given. The standard deviation about the mean is also shown. Figures 2, 3 and 4 depict seasonal changes in nutrient contents of station 2 (S.O.M. fractions). Table 4 contains dry weights of organic matter and nutrients in the organic portion of the S.O.M. and aquatic organisms drifting past the four stations on the Canagagigue Creek.

The dry weights of materials caught in the Bogardi Bedload Samplers are shown in Table 5.

Figure 5 depcits the relationship which exists between precipitation, discharge and quantities of drifting S.O.M. on a monthly basis as sampled at station 3 during 1975.

Table A of the Appendix contains the nutrient analysis results for each fraction on a monthly basis. Percentage organic matter as well as percentage Kjeldahl nitrogen and total phosphorus in the organic matter at each station were analyzed when sufficient material was obtained.

To determine if there were significant differences between the dry weights of individuals S.O.M. fractions drifting past upstream and downstream stations a paired t-test was conducted. In most cases there was no difference ($p=0.05$) between the amounts drifting past stations on the same branch. A few significant tests were obtained, however. There was a significant difference at the one percent level between the percentage of coarse coniferous material transported past stations 1 and 2. There was more coarse coniferous material caught at station 2. For the coarse green and deciduous fractions of stations 3 and 4 there was a significant difference at the 5% level in the weight transported.

Discussion

Table 1 shows that large differences in total weights of fine S.O.M. exist between stations located on the same branch of the stream. Further, the dry weight of aquatic organisms is small in comparison with the weights of other materials drifting downstream. The construction of organisms is greater in the West Branch than in the East.

Table 1 - Total Calculated Dry Weights (kg) of S.O.M. and Aquatic Organisms Moving Downstream past Each Station (Particle Size 253 micron - 1.0 cm)

Station	F.S.O.M.	Aquatic Organisms	Total
June 1'75- June 30'76			
1	32,129.72	39.54	32,169.26
2	4,185.15	43.70	4,228.85
June 1'75- Dec. 30'75, Mar. 29'76- June 30'76			
3	578.83	37.10	615.93
4	3,443.83	181.88	3,625.71

Tables 2A through D indicate the monthly fraction contributions at each station. At station 1 (Table 2A) material in the deciduous and algal fractions contribute the greatest dry weights to the 1.3 - 3.0 cm particle material. The greatest quantities of deciduous material in this size range moved downstream during the spring flush (March, 1976). June 1975 and 1976 were the most important months for drifting Cladophora at station 1. The detritus-algal fraction followed by the deciduous fraction contributed the greatest weights of S.O.M. in the particle size range 253 micron - 1.0 cm. The greatest quantities of material drifted during March 1976.

Almost 80% of the coarse S.O.M. drifting past station 1 during the 13 month sampling period did so during March and April of 1976. During these two months 95% of the 13 month fine S.O.M. drifted past station 1. Dickinson et al (1975) state that in Southern Ontario 50% of suspended loads move downstream during the months of March and April.

At station 2 coarse S.O.M. consists primarily of deciduous and coniferous material. The greatest quantities of coarse deciduous material drifted downstream during April 1976. June and December 1975 as well as February and March 1976 all contributed 10 or more kilograms of deciduous material to the 13 month total. Large quantities of cedar needles drifted past station 2 from October through December 1975. Coarse S.O.M. seems to move downstream past station 2 in sustained quantities throughout the year. However, during January when light ice cover occurred little material drifted downstream.

At station 2 the months of March and April 1976 contributed only 25% of the 13 month total of drifting coarse S.O.M. This result is in sharp contrast to the situation at station 1.

Station 2 is located at the downstream edge of a beech-sugar maple woodlot. The stream bottom here consists of

Table 2 - A Monthly Contribution of each fraction (dry weight kg) to total calculated S.O.M. drifting in the East Branch of Canagagigue Creek.

Station 1

Month	1.3 - 3.0 cm particles				253 micron-1.0 cm particles			
	Green	Conifer	Decid.	Algae	Green	Conifer	Decid.	Detritus + Algae
June 1975	1.11	0.33	5.16	3.83	0.35	0.20	2.06	107.04
July	0.23	0.02	0.27	1.51	0.07	0.04	0.20	74.14
Aug	0.35	0.03	0.94	1.56	0.03	0.09	8.85	371.09
Sept	0.17	0.007	0.06	0.86	0.08	0.02	0.12	36.29
Oct	0.08	0.08	0.16	0.49	0.04	0.17	0.14	16.71
Nov	0.25	0.17	0.15	1.53	0.03	0.18	0.12	13.66
Dec	0.27	0.09	1.64	1.75	0.42	0.38	6.31	38.57
Jan 1976	0.18	0.03	0.16	0.19	0.79	1.07	0.64	186.00
Feb	0.67	0.04	1.57	0.13	0.33	0.10	0.13	152.01
Mar	6.70	0.85	109.56	0	60.43	33.24	268.94	29853.01
Apr	2.57	1.64	36.90	0.01	1.44	1.33	9.56	502.22
May	0.49	0.42	4.06	1.98	0.01	0.03	0	128.85
June	0.83	0.13	1.01	10.39	0.13	0.06	0.32	231.68
Total	13.9	3.84	161.64	24.23	64.15	36.91	297.39	31731.27

Table 2 - B
Monthly contribution of each fraction (dry weight, kg) to total calculated S.O.M. drifting in the East Branch of Canagagigue Creek

Station 2

Month	1.3 - 3.0 cm particles				253 micron - 1.0 cm particles			
	Green	Conifer	Decid.	Algae	Green	Conifer	Decid.	Detritus + Algae
June 1975	7.66	6.97	9.56	7.98	1.33	3.39	3.39	353.10
July	0.75	0.25	1.01	0.41	0.32	0.87	1.67	72.72
Aug	1.30	1.23	7.40	3.50	0.50	0.89	2.08	83.64
Sept	0.50	1.32	5.53	1.35	0.24	1.55	1.22	57.49
Oct	0.07	5.61	4.58	0.44	0.04	2.65	1.82	15.29
Nov	0.37	8.35	3.26	1.32	0.16	6.27	1.12	30.62
Dec	0.51	6.42	9.75	0.71	0.22	5.56	2.19	78.07
Jan 1976	0.02	0.28	0.24	0	0.01	0.42	0.07	4.31
Feb	5.85	4.44	11.53	0	0.90	8.48	12.49	250.94
March	0.45	1.60	13.99	0.11	10.05	14.52	52.73	2,156.63
April	0.56	4.04	25.52	0	0.08	0.96	1.35	434.52
May	0.54	2.54	8.99	0	0.14	1.10	1.02	153.37
June	2.20	3.38	7.13	0	3.03	2.57	2.96	344.09
Total	20.78	46.43	108.49	15.82	17.02	49.23	84.11	4,034.79

Table 2 C

Monthly contribution of each fraction (dry wt., kg) to total calculated S.O.M. drifting in the West Branch of Canagagigue Creek

Station 3

Month	1.3 - 3.0 cm particles Green	Decid.	Algae	253 micron - 1.0 cm particles Green	Decid.	Detritus + algae
June 1975	0.98	6.10	9.73	0.002	0.04	3.92
July	0.02	0.02	1.10	0.0007	0.002	1.86
Aug	0.15	0.37	1.86	0.03	0.48	90.47
Sept	0.006	0.03	0.12	0.02	0.11	103.06
Oct	0.005	0.06	0.18	0	0.0003	3.64
Nov	0.004	0.03	0.02	2.41	7.14	34.14
Dec	0.05	0.07	0.05	0.78	2.65	149.85
Apr 1976	0.51	4.48	0.005	1.67	1.98	82.83
May	0.96	6.98	37.72	0	0	71.28
June	0.02	0.62	1.91	0.18	0.05	20.24

Table 2 D

Station 4

Month	1.3 - 3.0 cm particles Green	Decid.	Algae	253 - 1.0 cm particles Green	Decid.	Detritus + algae
June 1975	12.13	7.67	11.05	0	1.26	1,401.76
July	0.01	0.18	1.90	0	0.01	3.03
Aug	0.12	28.58	7.95	0	20.02	175.19
Sept	3.92	16.33	10.59	0.60	6.20	233.82
Oct	0.99	3.00	3.23	0	0.38	18.94
Nov	8.33	42.56	6.08	5.88	82.73	187.56
Dec	12.59	0.22	0	64.40	250.83	797.00
Apr 1976	2.19	19.67	0	0.51	1.42	82.45
May	0.60	37.04	3.20	0.47	3.54	77.10
June	0.23	1.70	46.26	0.13	1.39	27.21

large cobbles up to 30 cm in diameter. The stream bed is quite wide and thus increases in discharge are accommodated with less change from base conditions than occurs at station 1. It is reasonable to suggest that these physical conditions prevent allochthonous material from moving downstream in large pulses.

Similarily the quantities of fine S.O.M. drifting past station 2 are much less than those past station 1. Approximately 60% of the 13 month total of fine S.O.M. drifted past station 2 during March and April. Bormann et al (1969) found that, with the exception of an unusual storm, 70% of all particulate matter was transported in Watershed 6 of the Hubbard Brook Forest during the late winter-spring runoff period.

At stations 3 and 4 no coniferous material was present. At station 3 algae contributed the greatest quantities to coarse S.O.M. At station 4 the deciduous fraction was followed by the algal contribution to coarse S.O.M.

Detritus and algae contributed the largest amounts of material to the fine S.O.M. at both stations. Small quantities of material drift downstream during months of low discharge on the intermittent West Branch (e.g. July and October 1975).

At all stations, in the present study, greater qualities of fine S.O.M. are transported than the quantities in a heterotrophic stream system in New Hampshire. Fisher and Likens (1973) found that 66% of the annual energy input is exported downstream primarily in the form of dissolved matter and that much smaller quantities of coarse (CPOM) and fine particulate organic matter (FPOM) moved downstream. In the New Hampshire study the quantities of CPOM were over 4 times those of FPOM. However the particle size in their CPOM and FPOM fractions were greater than 1 mm and particles retained on glass fibre filters to 1 mm respectively. Brinson (1976) found that in the humid tropics the major form of organic matter transport in running waters is in the form of dissolved organic matter.

It is essential to determine the amounts of S.O.M. drifting downstream in both branches of the Canagagigue Creek. However the objective of this study is to determine the quantities of nutrients contained within this organic matter. Table 3 summarizes the nutrient analysis results for monthly bulked S.O.M. fractions. The mean percentages of organic matter Kjeldahl nitrogen and total phosphorous in the organic matter are basically similar for each fraction.

The percentage of organic matter is greatest in the coniferous fraction followed in decreasing order by deciduous, detritus and algae and lastly by the algal fractions. The filamentous branches of <u>Cladophora</u> become clogged with large quantities of inorganic particles.

The percentages of N and P in the organic matter of the fractions were ranked as follows:
algae > detritus and algae > green > deciduous > leaves > conifer.

To determine whether a significant difference existed in percentage organic matter, N orP between the two particle sizes of materials a paired t-test was conducted. Station 2 green, conifer and deciduous fractions were compared since the most complete nutrient analysis results existed for this station. It was found that no significant difference existed for this station at the 95% level in nutrient content of the two particles sizes. Similarily it is expected that no significant difference exists at any of the other stations between the two particle size nutrient contents.

For all fractions the percent O.M. at station 3 was less than at station 4, however the % N and P in the organic matter at station 3 was greater than at station 4.

The nutrient analysis results for fractions on a monthly basis are contained in Table A of the Appendix. These results show that at all stations the percentage of organic matter in the detritus-algae fraction was highest or high during October. There may be two explanations for this. During

Table 3

Summary of Nutrient Analysis Results for Drifting S.O.M. in the Canagagigue Creek June 1, 1975 - June 30, 1976. Mean percentages and standard deviations of organic matter, Kjedahl nitrogen and total phosporous in the organic matter for monthly bulked S.O.M. fractions

Mean Percentage Organic Matter

Particle size Station	1.3 - 3.0 cm Green $\bar{X}$	S.D.	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Algae $\bar{X}$	S.D.	253 micron - 1.0 cm Green $\bar{X}$	S.D.	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Detritus + Algae $\bar{X}$.	S.D.
1	64.8	15.37	81.4	8.88	62.9	9.44	37.7	5.56	75.5	4.53	84.7	4.72	71.5	7.48	34.0	13.98
2	67.0	13.34	85.3	5.62	69.3	10.70	37.7	9.27	73.6	4.27	82.2	3.29	76.5	4.63	36.1	17.58
3	61.2	17.91	-	-	56.6	14.81	31.0	9.05	61.9	20.77	-	-	70.4	8.11	32.3	17.54
4	73.7	9.10	-	-	73.5	8.38	34.0	8.58	80.1	7.75	-	-	79.4	10.43	39.4	28.07

Mean Percentage Kjeldahl Nitrogen in Organic Matter

Station	Particle size 1.3 - 3.0 cm Green $\bar{X}$	S.D	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Algae $\bar{X}$	S.D.	253 micron - 1.0 cm Green $\bar{X}$	S.D.	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Detritus + Algae $\bar{X}$	S.D.
1	4.23	2.49	1.35	0.14	2.61	0.67	4.89	0.84	3.31	0.39	1.17	0.20	2.24	0.62	3.63	1.05
2	3.96	1.71	1.32	0.12	2.04	0.49	5.71	1.62	3.26	0.78	1.40	0.23	1.91	0.27	3.99	1.46
3	3.24	0.70	-	-	2.73	0.51	5.96	1.00	3.30	0.72	-	-	2.30	0.51	4.46	1.90
4	2.97	0.96	-	-	2.09	0.34	5.39	1.25	3.00	0.40	-	-	2.89	0.55	4.45	3.35

Mean Percentage Total Phosphorous in Organic Matter

Station	Particle size 1.3 - 3.0 cm Green $\bar{X}$	S.D.	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Algae $\bar{X}$	S.D.	253 micron - 1.0 cm Green $\bar{X}$	S.D.	Conifer $\bar{X}$	S.D.	Decid. $\bar{X}$	S.D.	Detritus + Algae $\bar{X}$	S.D.
1	0.50	0.34	0.10	0.01	0.31	0.10	0.57	0.21	0.31	0.03	0.23	0.35	0.20	0.08	0.47	0.17
2	0.45	0.26	0.09	0.02	0.19	0.08	0.77	0.20	0.31	0.13	0.11	0.09	0.14	0.03	0.54	0.23
3	0.37	0.08	-	-	0.33	0.11	0.79	0.15	0.33	0.10	-	-	0.23	0.07	0.53	0.18
4	0.29	0.09	-	-	0.17	0.04	0.63	0.19	0.27	0.04	-	-	0.14	0.06	0.47	0.37

October, 1975 discharge was quite low and thus little gravel and sand was stirred up which would decrease the percentage of organic matter in the detritus fraction during October.

The highest percentages of N in algae at station 1 and 2 occurred during September and October and at stations 3 and 4 during May and October. On the East Branch the highest percentage N in the detritus-alga fraction was during July. However the highest percentage N in detritus-alga on the West Branch were during November and December.

The highest percentage of P in the green fraction for the East Branch particles 1.3 - 3.0 cm occurred during October. The highest percentages of P in various fractions from the West Branch stations were as follows: leaves - September; algae - October; detritus and algae - November. The highest percentages of P in various fractions for the East Branch stations were as follows: detritus + algae - July; green - October; leaves - November; conifer - January, February, March, April.

Several general conclusions may be drawn from these results. The percentage of N and P in the organic matter of many fractions was highest during September, October or November depending upon the fraction. This is to be expected since nutrient buildup occurs in certain plant tissues during the growing season and would be highest at the end of the season.

The most complete set of nutrient analysis results was obtained for station 2 monthly bulk S.O.M. fractions. June 1975 to December 1975 analysis results were subjected to analysis of variance. It was shown that there was no significant difference ($p=0.05$) between L.O.I., % N and % P in different fractions. It is probable that this is so at the other three stations also.

Similarly ANOVA on the basis of annual mean L.O.I., % N and % P among the four stations showed no difference ($p=0.05$) between the nutrient contents of material coming from different stations.

Figures 2, 3 and 4 show the changes in organic matter and nutrient percentages in fractions of materials drifting past station 2 during the 13 month sample period.

Certain fractions e.g. coniferous and deciduous show little change in their composition during the year. The percentage organic matter as measured by L.O.I. and the percentage of nutrients in the organic matter fluctuates within narrow limits in these two fractions. No definite trends appear in these fluctuations except that the phosphorus content of deciduous leaf material (1.0 - 3.0 diameter) increases from September until May and then decreases by over 0.2%. Other workers have shown that leaf material which has been colonized by fungi increases in nutrient content. The P content of coniferous material increased slowly from December until June, 1976 also.

Much greater fluctuations in nutrient percentages occur throughout the season in the green algae and detritus-algae fractions. Nutrient concentrations in the green fraction increase during the growing season and peak in October. Algae exhibit a similar phenomenon with peak nutrient concentrations being reached in September. Great fluctuations occur in the organic content and nutrient percentages of organic matter in the detritus-algae fraction. It is well known that the exchange of nutrients between sediments and the overlying water is a dynamic process.

There seems to be a direct correlation between the fluctuations and actual readings of N and P percentages as shown in figures 3 and 4. West Branch values exhibit similar correlations between percent Kjeldahl nitrogen in organic matter and percentage total phosphorus in organic matter. This remarkable correlation between N and P in each fraction is unexplained as yet.

The nutrient contents of S.O.M. drifting in the Canagagigue Creek seem comparable with those of similar materials as stated in the literature (Gosz et al 1972, Wile and McCombie 1972, Wong and Clark 1976).

FIGURE 2. % ORGANIC MATTER (L.O.I.)

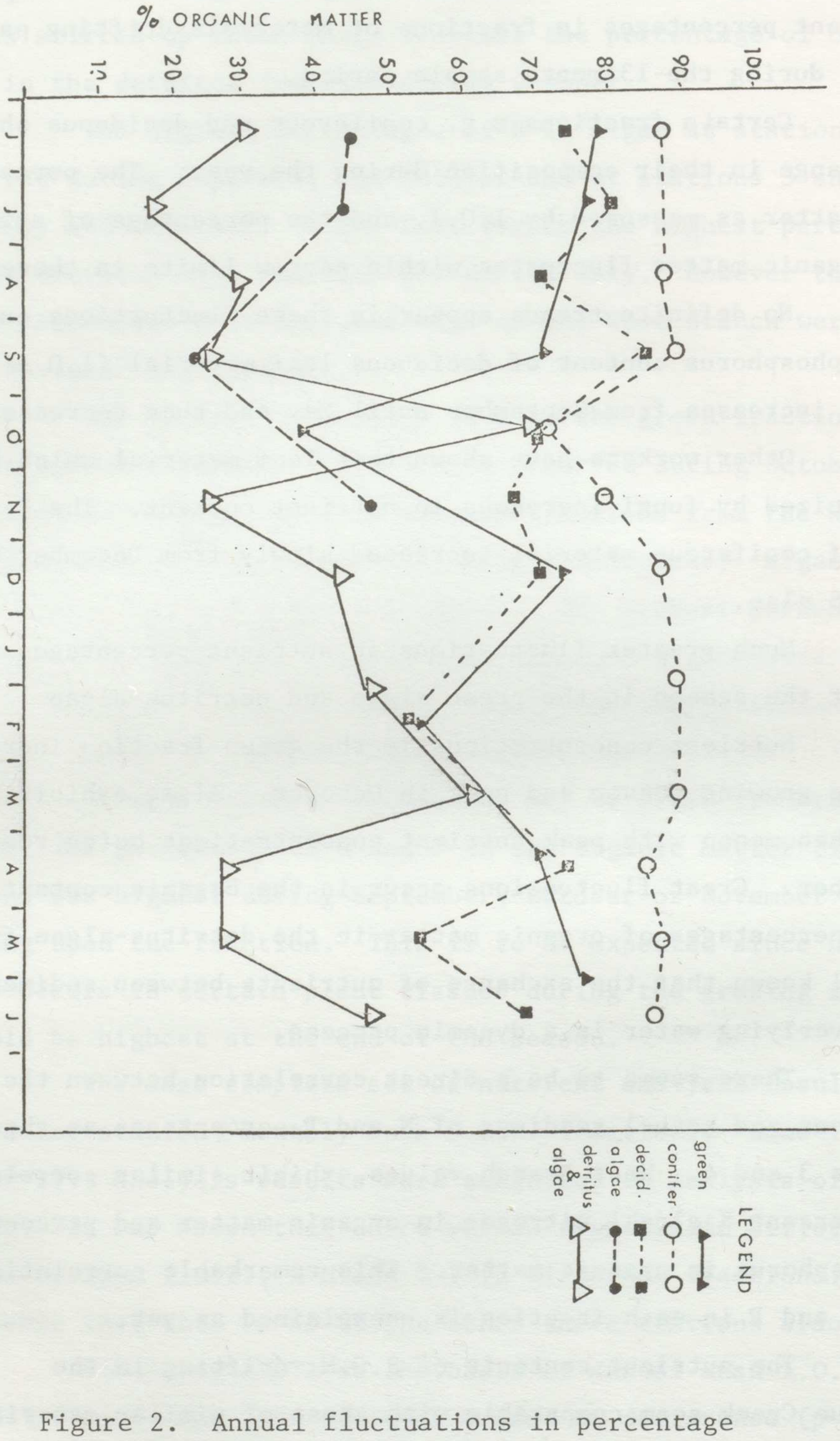


Figure 2. Annual fluctuations in percentage organic matter as determined by loss on ignition for station 2 monthly bulked samples. C.S.O.M. fractions and F.S.O.M. detritus-algae fraction values are graphed.

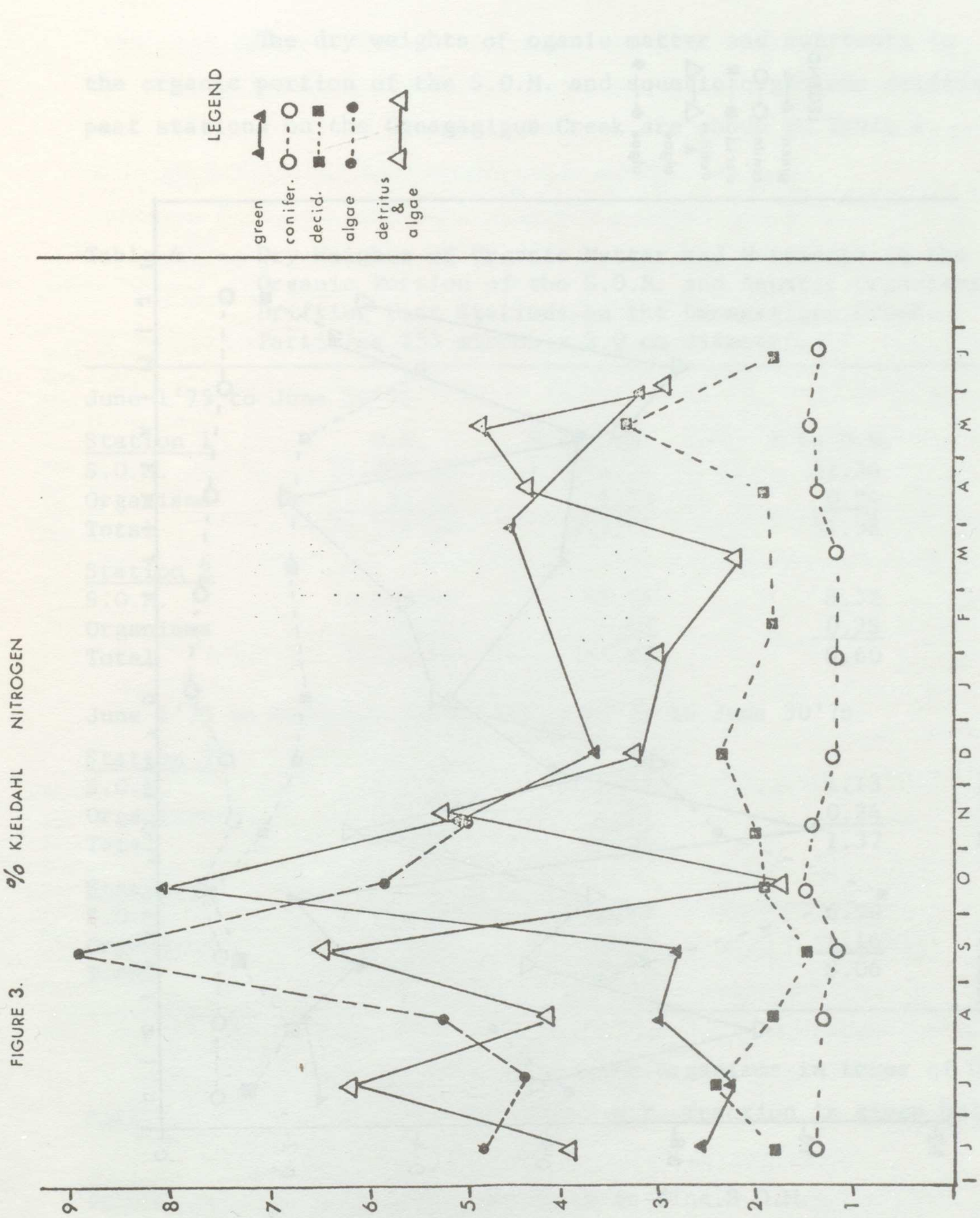


Figure 3. Annual fluctuations in percentage Kjeldahl nitrogen in organic matter of station 2 monthly bulked samples. C.S.O.M. fractions and F.S.O.M. detritus-algae fraction values are graphed.

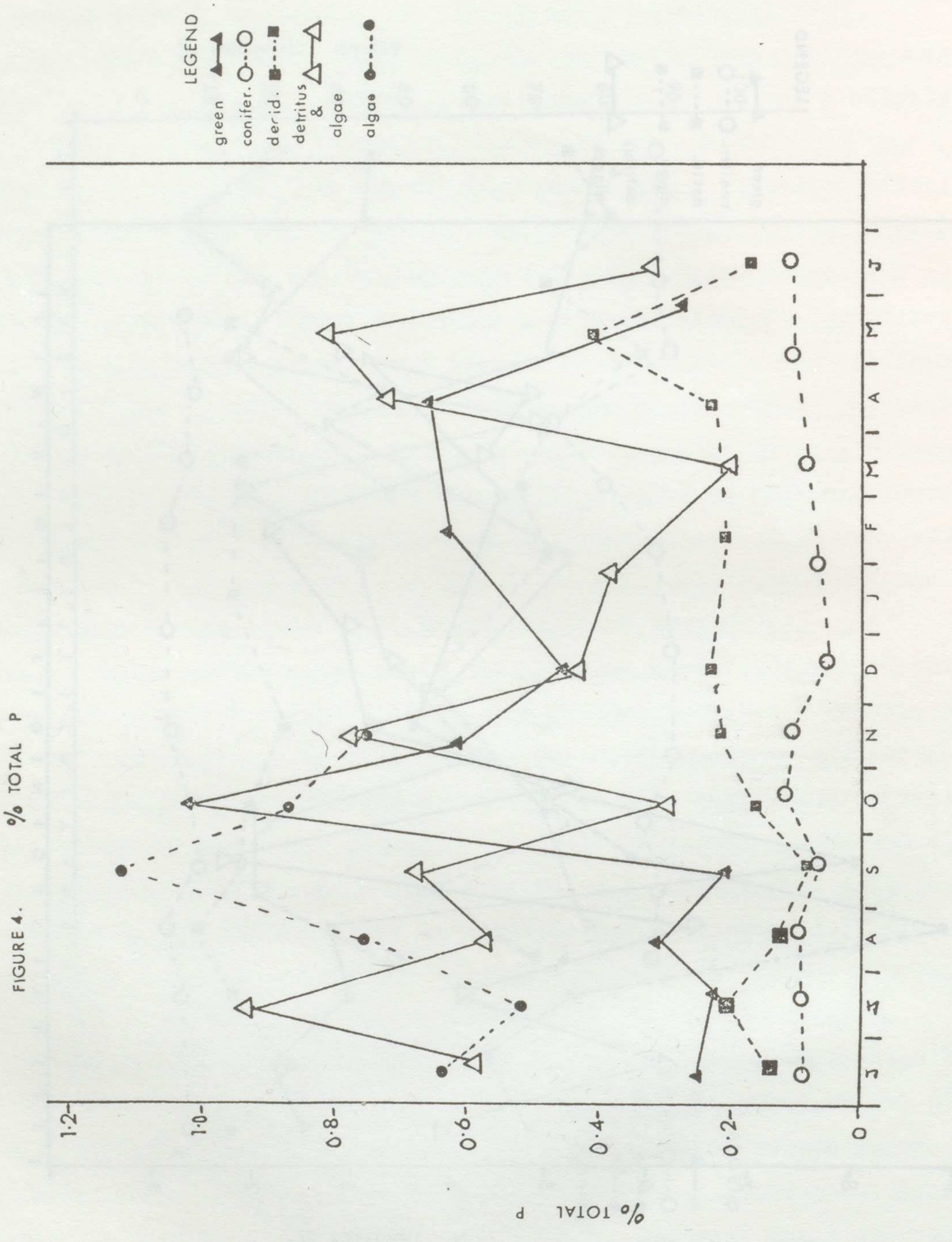


Figure 4. Annual fluctuations in percentage total phosphorus in organic matter of station 2 monthly bulked samples. C.S.O.M. fractions and F.S.O.M. detritus-algae fraction values are graphed.

The dry weights of oganic matter and nutrients in the organic portion of the S.O.M. and aquatic organisms drifting past stations on the Canagagigue Creek are shown in Table 4.

Table 4 - Dry Weights of Organic Matter and Nutrients in the Organic Portion of the S.O.M. and Aquatic Organisms Drifting Past Stations on the Canagagigue Creek. Particles 253 micron - 3.0 cm diameter.

June 1'75 to June 30'76			
Station 1	O.M.	N in O.M.	P in O.M.
S.O.M.	11,080.95	398.34	51.34
Organisms	33.61	1.29	0.24
Total	11,114.56	399.63	51.58
Station 2			
S.O.M.	1,573.87	63.24	8.32
Organisms	37.14	1.43	0.28
Total	1,611.01	64.67	8.60
June 1'75 to December 30'75, March 29'76 to June 30'76			
Station 3			
S.O.M.	217.94	9.32	1.13
Organisms	31.54	1.21	0.24
Total	249.48	10.53	1.37
Station 4			
S.O.M.	1,554.29	66.81	6.90
Organisms	154.62	5.95	1.16
Total	1,708.91	72.76	8.06

The contribution of aquatic organisms in terms of O.M. Kjeldahl N and total P to the fine S.O.M. fraction is given below.

Percentage that organisms contribute to fine S.O.M.

	Station 3	Station 4
Dry Weight	3.75	5.0
Organic Matter	13.0	9.0
Kjeldahl N in O.M.	11.0	8.0
Total P in O.M.	17.5	14.0

At stations 1 and 2 the contribution of organisms to the quantity of nutrients drifting downstream is quite low (< 2%).

At stations 3 and 4 however an important contribution is made by organisms to the downstream transport of N and especially phosphorus.

At station 1 it has been determined that 399.6 kg of N and 51.58 kg of P drifted downstream in the form of solid organic matter as fine and coarse S.O.M. during the 13 month sampling period. Only 64.7 kg of N and 8.6 kg of P drifted past station 2 as S.O.M. during the same period. At station 4 a quantity of N and P almost equal to that at station 2 drifted past between June 1 and December 30, 1975.

At station 3 small weights of N and P moved downstream during the 11 months of effective sampling. However large quantities are thought to have been transported during the spring flush.

Burwell et al (1974) report annual mean quantities of N and P discharged from two agricultural watersheds. For a 33.6 ha countour corn watershed 27.31 kg of N and o.967 kg of P was calculated to have been discharged by water and sediment transport. A 157.5 ha level-terraced watershed discharged 6.11 kg N and 0.447 kg P. The stream which passes station 1 drains 730.2 ha.

Bormann et al (1969) found that 94.1% of the annual gross losses of N from Watershed 6 Hubbard Brook Forest occurred as dissolved substances whereas only 5.9% was contained in organic particulate matter.

Table 5 contains the dry weights of bedload material collected at stations 1 and 3.

Particles in the two size ranges less than 500 microns were observed to contain fine particles of organic matter. Coarse particles of organic matter were contained in the greater than 2 mm size fraction.

During the time intervals when the sampler was functional considerable quantities of bedload were encountered.

An examination of the discharge during periods when

Table 5

Bogardi Bedload Samples
Dry Weight (grams)
Collected from a stream bottom width of 12.5 cm.

Station 1

Sample Interval	150 micron	150-500 micron	500-840 micron	840 micron-2mm	2mm	Total
July 17-29/75	1.81	5.48	4.42	-	-	11.71
Aug 7-Nov 4	121.09	257.3	198.3	214.1	513.7	1,304.5
Nov 4-11	10.7	37.0	11.0	8.4	31.5	90.60
Nov 18-Dec 23	221.3	405.4	224.7	252.6	796.2	1,900.20
Dec 23-Jan 27	100.4	377.71	236.3	472.6	2,009.9	3,196.90
Mar 17-23/76	587.5	3,150.0	936.8	496.0	3,600.0	8,770.30
Mar 23-Apr 16	98.8	536.5	538.9	122.3	182.6	1,479.10
Apr 16-27	64.4	385.5	168.0	88.4	309.5	1,015.80
Apr 27-May 12	98.0	383.6	303.6	114.0	97.0	996.20
May 12-June 2	40.4	174.7	94.6	66.4	53.5	429.60
Totals						19,194.91
July 17-Jan 27	455.30	1,082.88	674.72	947.70	3,351.30	
Mar 17-june 2	889.10	4,630.30	2,041.90	887.10	4,242.60	

Station 3

Sample Interval	150 micron	150-500 micron	500-840 micron	840 micron-2mm	72mm	Total
Jul 16-Sep 16/75	345.52	85.91	2.22	39.03	-	472.68
Sep 16-Oct 28	256.5	93.1	3.78	30.06	-	383.44
Oct 28-Nov 18	95.5	61.0	17.8	18.5	10.0	202.80
Mar 29-Apr 9/76	416.6	843.0	1,798.4	2,003.0	1,810.0	6,871.00
Apr 9-May 4	375.0	959.7	2,896.3	2,910.3	1,396.8	8,538.10
May 4-May 18	174.2	524.0	2,490.0	394.0	1,648.0	5,230.20
May 18-June 2	39.5	51.7	75.3	53.3	46.0	265.80
Totals						21,964.02
July 16-Nov 18	697.52	240.01	23.80	87.59	10.0	
Mar 29-June 2	1,005.30	2,378.40	7,260.0	5,360.60	4,900.80	

the bedload sampler was used, indicates that more bedload moves during high discharge conditions than during periods of base flow. For example at station 1 the small quantities moving between November 4 and 11, 1975 were a result of low stable discharge (4 cfs). March 17-23, 1976 represents a pre-spring flush interval of high discharge (55 cfs) during which the highest amounts of bedload were recorded. It is probable that large quantities of bedload move downstream during the spring flush itself. The sampler could not be used under the high discharge conditions prevalent on the Canagagigue during the spring flooding. Late spring spates April 25 (26 cfs) and May 6 (21 cfs) were responsible for the quantities of bedload moved between April 27 and May 12 and May 12 to June 2 respectively.

At station 3 the low values of bedload movement during the summer and fall of 1975 result from the fact that the West Branch is an intermittent stream. The 8.5 kg of bedload between April 9 and May 4, 1976 resulted from two high discharge events (April 16 - 33 cfs and April 27 - 75 cfs). The low discharge conditions between May 18 and June 2 resulted in low values of bedload.

The material in the fraction sizes between 500 micron and 2 mm would have also been caught by the nylon drift monitor.

There are several obstacles to calculating the total amounts of bedload moving downstream past a given point. One of these is the fact that those samples are only about 75% efficient (Comer and Floess 1975).

We did not determine the amount of nutrients associated with this bedload material. However during periods of high discharge much of the material sampled by the vertical nylon monitor was bedload essentially. Thus these values of percent organic matter, N and P could be applied to certain bedload size fractions.

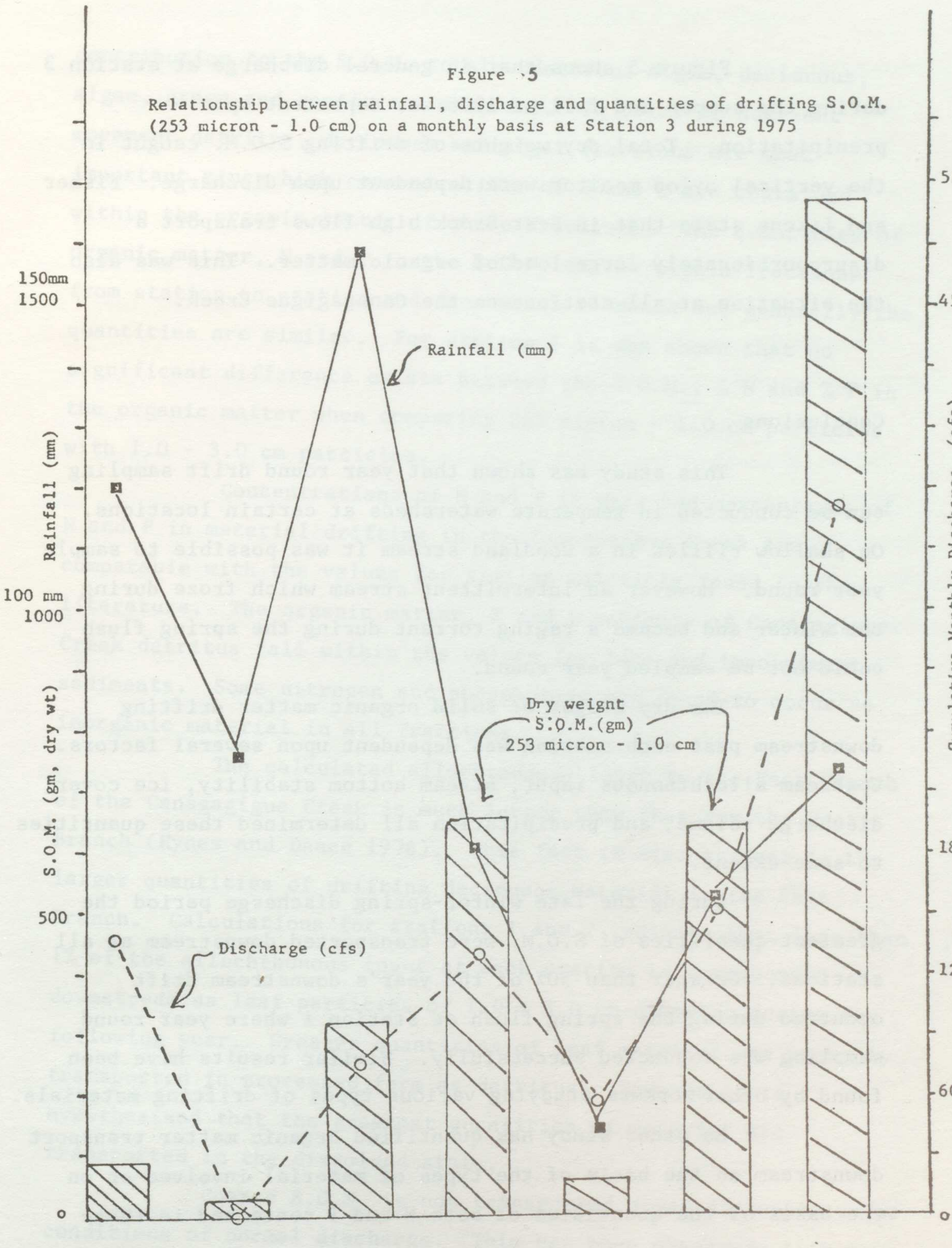


Figure 5

Relationship between rainfall, discharge and quantities of drifting S.O.M. (253 micron - 1.0 cm) on a monthly basis at Station 3 during 1975

Figure 5 shows that in general discharge at station 3 during the summer and fall of 1975 was dependent upon precipitation. Total dry weights of drifting S.O.M. caught in the vertical nylon monitor were dependent upon discharge. Fisher and Likens state that in Bear Brook high flows transport a disproportionately large load of organic matter. This was also the situation at all stations on the Canagagigue Creek.

Conclusions

This study has shown that year round drift sampling can be conducted in temperate watersheds at certain locations. On shallow riffles in a woodland stream it was possible to sample year round. However an intermittent stream which froze during the winter and became a raging torrent during the spring flush could not be sampled year round.

The dry weight of solid organic matter drifting downstream past each station was dependent upon several factors. Upstream allochthonous input, stream bottom stability, ice cover, discharge volume, and precipitation all determined these quantities to some extent.

During the late winter-spring discharge period the greatest quantities of S.O.M. were transported downstream at all stations. Greater than 50% of the year's downstream drift occurred during the spring flush at station 1 where year round sampling was conducted successfully. Similar results have been found by other workers studying various types of drifting materials.

No other study has quantified organic matter transport downstream on the basis of the types of material involved or on the basis of the quantities of both N and P contained in these material types.

In the Canagagigue Creek the following fractions were important in descending order as concerns their weight contribution to the S.O.M. total: detritus-algae, deciduous, algae, green and coniferous material. In terms of nutrient movement detritus, deciduous and algal fractions are most important since high concentrations of N and P are contained within the organic matter of these fractions. The quantities of organic matter, N and P in the S.O.M. differ within fractions from station to station and from month to month but generally the quantities are similar. For station 1 it was shown that no significant difference exists between the % O.M., % N and % P in the organic matter when comparing 253 micron - 1.0 cm particles with 1.0 - 3.0 cm particles.

Concentrations of N and P in mg/g and percentages of N and P in material drifting in the Canagagigue Creek are comparable with the values for similar materials found in the literature. The organic matter, N and P contents of Canagagigue Creek detritus fall within the values for lake and impoundment sediments. Some nitrogen and phosphorous was found to occur as inorganic material in all fractions.

The calculated allochthonous input to the East Branch of the Canagagigue Creek is much larger than that for the West Branch (Hynes and Dance 1976). This fact is also evident in the larger quantities of drifting deciduous material in the East Branch. Calculations for stations 1 and 2 indicate that less than 1% of the allochthonous input at each station is transported downstream as leaf particles of 1.0 - 3.0 cm diameter during the following year. Greater quantities of leaf material are probably transported in processed form as detritus. However it is hypothesized that the greatest quantities of material are transported in the dissolved state.

Coarse S.O.M. is not transported great distances under conditions of normal discharge. This has been observed qualitatively but the fact that more coarse coniferous material was caught at station 2 (within a woodlot) then at station 1 (approximately 300 m downstream of a woodlot) substantiates these observations. Wilson and Bright (1973) found that tiny balls which they released in a river generally travelled less than 400 m.

Consideration of the macroinvertebrate drift caught in the vertical nylon monitor (Dance, unpublished) has revealed several interesting points which bear upon the present conclusions. The distances travelled by drifting aquatic organisms has been documented and is usually much less than 100 m (Elliott 1971). Comparison of the numbers of drifting macroinvertebrates with those found by other authors (Bishop 1968, Ulfstrand 1968, Clifford 1972) shows that the vertical nylon monitor functions efficiently. The contribution to the total dry weight of drifting material made by animals varies from station to station. However since nutrient concentrations are higher in macroinvertebrates than in any of the vegetable materials these animals are of importance. At the West Branch stations relatively large quantities of N and P are transported as aquatic invertebrates.

The Bogardi Bedload Sampler results indicate that large quantities of material move downstream as bedload during the ice-free season. Bedload transport seems to be positively correlated with discharge volume. Since stream sediments are known to play an important role in nutrient flux intensive sampling of agricultural stream bedload would be a worthwhile undertaking.

Discharge was found to be a function of precipitation and in turn the amounts of drifting S.O.M. was found to be dependent upon discharge. Land use activities, relative differences in underlying geology and stream recharge also affect the discharge regimes of the two study streams.

Relationship of Project Results to PLUARG Objectives

The present study has quantified the amounts of solid organic matter (253 micron - 3.0 cm particle size) and bedload which move downstream in two streams within an agricultural watershed. The total quantities of nutrients (Kjeldahl nitrogen and total phosphorous) within the organic matter were calculated. Thus a comparison of the contributions from two agricultural sub-watersheds can be made.

This study has determined which types of solid organic materials contribute the greatest quantities of nutrients to the stream. As well this study has confirmed that in agricultural watersheds most downstream transport of material occurs during the spring flush. However during most of the year small quantities of solid materials move and these do not travel great distances. Whether these nutrients move downstream in the dissolved state was to be determined by another group of workers.

This study has contributed to our knowledge of the transport of materials from agricultural watersheds to the Great Lakes.

Recommendations

1) Further research the importance of stream sediments as regards their capacity to absorb and release phosphorus. Study in detail sediment transport.

2) Determine the importance of macroinvertebrates and the green algae <u>Cladophora</u> in the processing/cycling of nutrients in agricultural streams.

3) Improve water quality in agricultural watersheds by considering the implementation of the following land use improvements:

(a) curtail tree removal and land drainage in bottom lands;

(b) decrease bank erosion by tree planting and preventing cattle from trampling banks;

(c) control barnyard runoff by legislative and subsequent enforcement measures.

APPENDIX TABLE A

Results

Loss on ignition $\bar{X}$ 3 reps

% Organic Matter

Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper East

Month	Particle Size 1.30-3.0 cm Green	Conifer	Decid. Leaves	Alga	Particle Size 253 micron-1.0 cm Green	Conifer	Decid.	Detritus-Alga
June 75	71.4	89.73	64.5	38.3	75.2	85.8	78.0	42.6
July	68.0	-	69.8	39.3	-	81.0	72.7	13.8
Aug	76.6	-	78.9	46.1	-	-	61.6	20.2
Sept	72.9	-	60.8	34.1	79.5	-	65.9	36.8
Oct	23.9	65.8	70.4	33.7	68.6	86.9	69.1	69.5
Nov	71.6	87.1	-	45.1	71.3	77.2	60.7	31.6
Dec	70.5	-	53.4	31.1	80.3	90.1	77.1	29.7
Jan 76	61.3	86.3	45.1	-				40.11
Feb				-	77.9	87.20	79.2	
Mar	53.0		58.4	-				36.8
Apr	64.5	76.6	65.8	-			79.4	35.4
May	79.0	83.11	62.0	33.7	-	-	-	24.3
June								27.2
$\bar{X}$	64.79	81.43	62.91	37.67	75.50	84.70	71.52	34.00
S.D.	15.37	8.88	9.44	5.56	4.53	4.72	7.48	13.98

Lower East

Month	Particle Size 1.3-3.0 cm Green	Conifer	Decid. Leaves	Alga	Particle Size 253 micron-1.0 cm Green	Conifer	Decid.	Detritus-Alga
June 75	79.4	87.46	74.0	44.6	72.4	85.9	76.2	29.5
July	78.2	-	80.0	44.1	76.7	81.0	71.3	16.0
Aug	74.0	87.2	70.7	33.2	-	82.4	82.8	28.5
Sept	71.1	89.4	85.5	22.3	-	84.6	81.3	23.9
Oct	35.9	70.2	69.6	35.4	68.1	89.7	79.5	72.11
Nov	57.1	80.5	67.1	46.6	-	87.6	72.5	24.7
Dec	73.9	86.0	71.5	-	75.7	91.3	69.1	42.5
Jan 76		89.7		-		85.8	74.80	45.80
Feb	53.8		53.32		69.6		81.1	61.3
Mar		89.02		-				21.0
Apr	71.1	85.2	73.9	-				21.6
May	75.3	87.5	47.9	-	79.04	87.8	76.81	46.7
June		86.5	69.2	-				
$\bar{X}$	67.73	85.33	69.33	37.70	73.59	86.23	76.54	36.13
S.D.	13.34	5.62	10.70	9.27	4.27	3.29	4.63	17.58

Table A cont'd.

Results

Loss on ignition X̄ 3 reps.

% Organic Matter

Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper West

	Particle Size 1.3-3.0 cm			Particle Size 253 micron - 1.0 cm		
Month	Green	Decid.	Alga	Green	Decid.	Detritus
June 75	73.4	59.9	34.7	80.3	79.9	48.7
July	78.2	-	40.7	-	-	25.7
Aug	84.3	52.8	31.5	66.7	71.3	34.0
Sept	-	83.3	43.5	-	73.3	13.2
Oct	-	62.8	22.4	-	-	75.6
Nov	51.3	54.7	-	-	57.2	18.5
Dec	-	71.9	22.8	77.1	76.4	19.7
Jan 76	55.3	36.11	-	75.8	71.13	29.7
Feb			-			
Mar			-			
Apr	51.3	45.3	-	37.2	74.7	36.33
May	34.3	42.7	21.7	34.3	58.9	20.1
June						33.0
X̄	61.15	56.61	31.04	61.90	70.35	32.23
S.D.	17.91	14.81	9.05	20.77	8.11	17.54

Lower West

	Particle Size 1.3-3.0 cm			Particle Size 253 micron - 1.0 cm		
Month	Green	Decid.	Alga	Green	Decid.	Detritus
June 75	72.8	-	30.2	72.4	75.6	7.2
July	65.9	-	-	-	-	21.1
Aug	83.4	81.9	35.1	-	76.7	35.3
Sept	77.3	77.8	38.4	71.4	57.3	15.5
Oct	89.8	82.3	28.1	-	-	79.9
Nov	70.8	81.8	46.6	-	76.7	10.4
Dec	-	71.7	-	85.6	88.1	77.7
Jan 76	75.6	73.53	-	89.1	90.2	85.13
Feb+						
Mar	67.1	69.7	-	86.2	86.3	48.3
Apr	57.2	58.1	-	-	88.9	46.7
May+	75.9	65.0	22.1	75.9	74.5	May 24.4
June						June 21.6
X̄	73.68	73.53	33.41	80.10	79.36	39.43
S.D.	9.10	8.38	8.58	7.75	10.43	28.07

Table A cont'd.
Results
% N Kjeldahl in organic matter
Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper East

Particle Size	1.3-3.0 cm				Particle Size 253 micron - 1.0cm			
Month	Green	Conifer	Decid. Leaves	Alga	Green	Conifer	Decid.	Detritus-Alga
June 75	2.95	1.39	2.04	3.73	2.87	1.47	1.87	3.04
July	3.40	-	2.50	4.62	-	1.27	-	5.78
Aug	2.97	-	2.06	4.48	-	-	1.41	3.63
Sept	4.04	-	2.99	5.84	3.36	-	2.67	3.62
Oct	11.7	1.32	2.96	5.60	-	0.96	2.56	1.79
Nov	3.78	1.08	-	5.65	-	-	3.34	4.80
Dec	3.77	-	3.05	5.41	3.82	1.03	2.49	3.87
Jan Feb	3.77	1.36	4.06	-	3.19	1.14	1.74	3.26
Mar	3.13		2.48	-				2.50
Apr	3.60	1.47	1.92	-			1.87	2.99
May+					-	-	-	4.02
June	3.52	1.47	2.02	3.81	-	-	-	4.26
$\bar{x}$	4.23	1.35	2.61	4.89	3.31	1.17	2.24	3.63
S.D.	2.49	0.14	0.67	0.84	0.39	0.20	0.62	1.05

Lower East

Particle Size	1.30-3.0 cm.				Particle Size 253 micron - 1.0 cm			
Month	Green	Conifer	Decid. Leaves	Alga	Green	Conifer	Decid.	Detritus-Alga
June 75	2.58	1.3[illegible]	1.73	4.81	2.91	1.64	1.81	3.88
July	2.39	-	2.36	4.49	2.24	1.56	-	6.07
Aug	3.09	1.29	1.73	5.29	3.14	1.66	1.69	4.12
Sept	2.84	1.16	1.52	8.90	-	1.44	1.94	6.37
Oct	8.16	1.56	1.95	5.84	-	0.95	2.17	1.83
Nov	5.10	1.43	2.07	4.95	-	1.23	2.16	5.31
Dec	3.68	1.20	2.33	-	4.55	1.22	2.15	3.20
Jan		1.20		-		1.47	2.21	2.96
Feb			1.80	-	3.69			
Mar	4.07	1.18		-			1.63	2.19
Apr	4.57	1.40	1.87	-				4.34
May		1.42	3.34	-	3.05	1.48	1.48	4.81
June	3.13	1.35	1.79	-				2.83
$\bar{x}$	3.96	1.32	2.04	5.71	3.26	1.40	1.91	3.99
S.D.	1.71	0.12	0.49	1.62	0.78	0.23	0.27	1.46

Table A cont'd.

Results

% N Kjeldahl in organic matter

Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper West

Month	Particle Size 1.3-3.0 cm: Green	Decid.	Alga	Particle Size 253 micron - 1.0 cm: Green	Decid.	Detritus + Alga
June 75	-	-	6.12	2.53	1.99	3.13
July	3.41	-	-	-	-	4.98
Aug	2.30	3.76	7.38	-	2.25	3.65
Sept	-	2.05	4.80	-	3.26	5.50
Oct	-	2.52	6.61	-	-	1.70
Nov	-	-	-	-	-	5.69
Dec	3.37	2.66	6.03	2.79	2.01	8.89
Jan 76	2.71	2.85	-	3.20	2.64	4.84
Feb			-			
Mar			-	-	-	
Apr	3.32	2.57	-	3.62	1.69	3.52
May + June	4.37	2.73	4.84	4.37	2.27	May 4.36 June 2.83
$\bar{X}$	3.24	2.73	5.96	3.30	2.30	4.46
S.D.	0.70	0.51	1.00	0.72	0.51	1.96

Lower West

Month	Particle Size 1.3-3.0 cm: Green	Decid.	Alga	Particle Size 253 micron - 1.0 cm: Green	Decid.	Detritus + Alga
June 75	2.92	1.68	4.99	2.79	2.31	1.70
July	-	-	3.65	-	-	5.04
Aug	2.60	1.70	4.76	-	2.61	4.54
Sept	3.13	2.58	5.23	3.53	3.31	6.64
Oct	1.82	1.95	7.06	-	-	1.64
Nov	5.19	2.35	4.98	3.53	2.51	13.98
Dec	-	2.42	-	2.46	1.84	2.55
Jan 76	2.91		-			
Feb+		2.47	-	3.05	1.88	2.42
Mar	1.98	1.67	-	2.78	1.70	3.22
April	3.30	2.06	-	-	1.59	2.75
May + June	2.87	2.01	7.07	2.87	1.88	3.59 5.03
$\bar{X}$	2.97	2.09	5.39	3.00	2.18	4.45
S.D.	0.96	0.34	1.25	0.40	0.55	3.35

Table A cont'd.

Results

% P in organic matter

Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper East

Month	Particle Size 1.3-3.0 cm Green	Conifer	Decid. Leaves	Alga	Particle Size 253 micron-1.0 cm Green	Conifer	Decid.	Detritus + Alga
June 75	0.27	0.10	0.22	0.50	0.26	0.13	0.18	0.36
July	0.38	-	0.25	0.54	-	0.09	0.15	0.86
Aug	0.54	-	0.22	0.49	0.30	-	0.15	0.50
Sept	0.22	-	0.36	0.86	0.34	-	0.28	0.42
Oct	1.45	0.09	0.42	0.29	-	0.06	0.29	0.23
Nov	-	0.08	-	0.79	-	-	0.36	0.60
Dec	0.44	-	0.32	0.78	0.34	0.01	0.19	0.42
Jan 76	0.57	0.11	0.53	-			0.10	0.38
Feb				-				
Mar	0.36		0.27	-	0.34	0.86		0.27
Apr	0.42	0.12	0.20	-			0.17	.0.42
May +	0.38	0.10	0.27	0.33	-	-	-	0.61 May
June					-	-	-	0.62 June
$\bar{X}$	0.50	0.10	0.31	0.57	0.31	0.23	0.20	0.47
S.D.	0.34	0.01	0.10	0.21	0.03	0.35	0.08	0.17

Lower East

Month	Particle Size 1.3-3.0 cm Green	Conifer	Decid. Leaves	Alga	Particle Size 253 micron-1.0 cm Green	Conifer	Decid.	Detritus + Alga
June 75	0.24	0.09	0.13	0.64	0.29	0.11	0.14	0.50
July	0.21	-	0.20	0.52	0.20	0.12	0.13	0.92
Aug	0.31	0.09	0.12	0.76	-	0.12	0.11	0.56
Sept	0.20	0.06	0.08	1.12	-	0.12	0.13	0.67
Oct	1.01	0.12	0.16	0.87	-	0.06	0.16	0.28
Nov	0.61	0.11	0.21	0.74	-	0.07	0.21	0.76
Dec	0.43	0.05	0.23	-	0.50	0.01	0.16	0.42
Jan 76	0.61	0.06	0.20	-		0.34	0.18	0.37
Feb				-	0.39			
Mar		0.08		-			0.10	0.19
Apr	0.65	0.09	0.23	-				0.71
May	0.26	0.10	0.41	-	0.19	0.10	0.10	0.80
June		0.10	0.16	-				0.31
$\bar{X}$	0.45	0.09	0.19	0.77	0.31	0.11	0.14	0.54
S.D.	0.26	0.02	0.08	0.20	0.13	0.09	0.03	0.23

Table A cont'd.

Results

% P in organic matter

Monthly Bulked S.O.M. Drifting in Canagagigue Creek

Upper West

Month	Particle Size 1.3-3.0 cm Green	Decid.	Alga	Particle Size 253 micron - 1.0 cm Green	Decid.	Detritus + Alga
June 75	-	-	0.78	0.23	0.25	0.37
July	0.35	-	-	-	0.24	0.69
Aug	0.26	0.54	0.87	-	0.21	0.53
Sept	-	0.22	0.59	-	0.36	0.83
Oct	-	0.30	1.04	-	-	0.27
Nov	-	-	-	-	-	0.81
Dec	0.35	0.20	0.81	0.27	0.13	0.66
Jan 76	-		-			
Feb	-	0.38	-	0.30	0.27	0.38
Mar	-		-			-
April	0.41	0.35	-	0.38	0.12	0.40
May + June	0.49	0.33	0.69	0.49	0.26	May 0.53 June 0.41
$\bar{X}$	0.37	0.33	0.79	0.33	0.23	0.53
S.D.	0.08	0.11	0.15	0.10	0.07	0.18

Lower West

Month	Particle Sixe 1.3-3.0 cm Green	Decid.	Alga	Particle Size 253 micron - 1.0 cm Green	Decid.	Detritus + Alga
June 75	0.26	0.16	0.62	0.25	0.18	0.08
July	-	-	0.28			0.53
Aug	0.18	0.11	0.50	-	0.20	0.63
Sept	0.30	0.15	0.74	0.31	0.26	0.82
Oct.	0.18	0.14	0.77	-	-	0.20
Nov	0.49	0.19	0.62	0.30	0.19	1.46
Dec	-	0.18	-	0.20	0.10	0.20
Jan 76 Feb+	0.34	0.22	-	0.32	0.12	0.22
Mar	0.26	0.15	-	0.28	0.10	0.28
Apr	0.34		-		0.06	0.32
May+ June	0.24	0.25	0.87	0.24	0.12	May 0.41 June 0.59
$\bar{X}$	0.29	0.17	0.63	0.27	0.14	0.47
S.D.	0.09	0.04	0.19	0.04	0.06	0.37

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